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MARINE PROTECTED AREA NETWORK PLANNING IN THE SCOTIAN SHELF BIOREGION: OBJECTIVES, DATA, AND METHODS

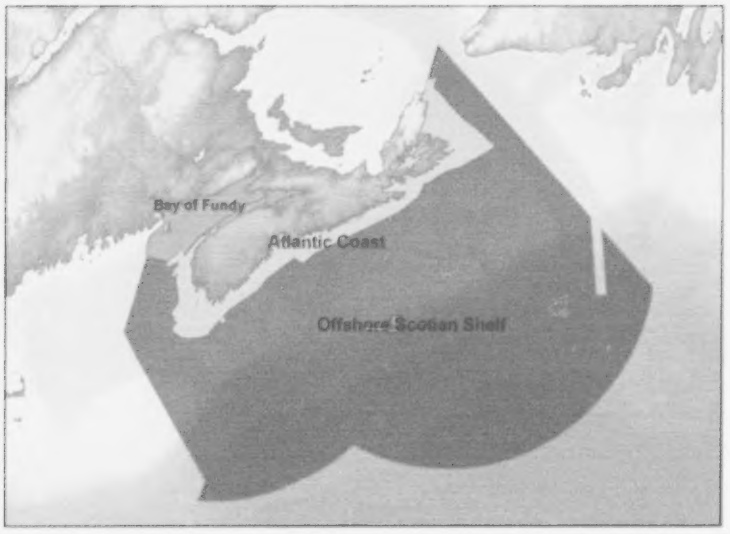

Figure 1. Location of three planning areas within the Scotian Shelf Bioregion: the Bay of Fundy (orange), the Atlantic Coast of Nova Scotia (lavender), and the Offshore Scotian Shelf (grey).

Context

Canada has committed to establishing a national network of marine protected areas (MPAs) in support of integrated coastal and ocean management. Fisheries and Oceans Canada (DFO), along with federal and provincial partners, is responsible for coordinating the development of MPA network plans for each of Canada's 13 bioregions. DFO Maritimes is leading the development of an MPA network plan for the Scotian Shelf Bioregion, which, for planning purposes, corresponds to the current DFO Maritimes Region boundary.

Guidance on bioregional MPA network planning is set out in the National Framework for Canada's Network of Marine Protected Areas (Government of Canada 2011) and in the Convention on Biological Diversity (CBD) Conference of the Parties Decision IX/20 (UNEP 2008). Annex II of the CBD Decision indicates that effective networks should include: Ecologically or Biologically Significant Areas (EBSAs), representativity, connectivity, replicated ecological features, and adequate and viable sites. Annex III suggests that the initial steps in designing networks of MPAs are to: (1) identify EBSAs, and (2) select or develop a suitable biogeographic, habitat, or community classification system that can be used as a basis for representativity. These steps are currently being undertaken in the Scotian Shelf Bioregion.

This Science Advisory Report (SAR) is from the March 5-7, 2012, meeting to review Marine Protected Area Network Planning in the Scotian Shelf Bioregion. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

SUMMARY

- Through prior DFO ocean planning work, the Scotian Shelf Bioregion was previously subdivided into three planning areas: Atlantic Coast of Nova Scotia, Bay of Fundy and Offshore Scotian Shelf.
- Two overarching conservation objectives proposed for a network of marine protected areas in the Scotian Shelf Bioregion were discussed at the meeting, and the following wording was considered to be consistent with national and international guidance:
  - Protect Ecologically or Biologically Significant Areas and other special natural features in the Scotian Shelf Bioregion that benefit from long-term, year-round, spatial management.
  - Protect representative examples of all marine ecosystem and habitat types in the Scotian Shelf Bioregion based on coastline, coastal subtidal, and offshore classifications, along with their associated biodiversity and ecological processes.
- While not explicitly stated in these overarching objectives, the connectivity between individual marine protected areas, replicated ecological features, and adequate and viable sites are also important considerations in marine protected area network design.
- More specific and measurable conservation objectives under the two overarching objectives may need to be developed for each of the three planning areas.
- Two separate but linked physiographic classification systems are recommended for the coastal zone, which are expected to largely reflect biological community patterns. Two distinct classification systems are recommended for consideration in the offshore.
- In the Bay of Fundy, sixteen areas were found to meet the DFO and Convention on Biological Diversity criteria for Ecologically or Biologically Significant Areas, using extensive literature review, scientific expert opinion, and validation with available data.
- For the Atlantic Coast of Nova Scotia, the scientific context and assessment process undertaken in 2010 to identify coastal areas that should be considered in conservation planning were reviewed. Twenty areas identified as meeting the criteria for Ecologically or Biologically Significant Areas were endorsed for consideration in the bioregional marine protected area network design phase. For 27 additional areas (also previously identified), it was recommended that they be re-evaluated against the Convention on Biological Diversity Ecologically or Biologically Significant Areas criteria, using expert knowledge and available regional information, to ensure potential priority areas for conservation, including those identified by Environment Canada, Parks Canada, and the Nova Scotia Government, have not been overlooked.
- Given the availability of various regional datasets for the Offshore Scotian Shelf, a data-driven and systematic approach, built on expert knowledge of the ecology of the area, the survey methodologies and the data sets, is proposed for identification of Ecologically or Biologically Significant Areas in this planning area.
- Further work is required to determine which of the identified Ecologically or Biologically Significant Areas (or parts thereof) should be included in the bioregional network of marine protected areas.
- Although difficult to predict, the potential implications of broad changes in the state of the ecosystem, including those due to climate change, should be taken into account in the marine protected area network design process.

BACKGROUND

The *National Framework for Canada's Network of Marine Protected Areas* (Government of Canada 2011), hereafter referred to as the *National Framework*, outlines the following primary goal for a Canadian network of marine protected areas (MPAs):

- To provide long-term protection of marine biodiversity, ecosystem function and special natural features.

Two secondary goals are also described:

- To support the conservation and management of Canada's living marine resources and their habitats, and the socio-economic values and ecosystem services they provide.
- To enhance public awareness and appreciation of Canada's marine environments and rich maritime history and culture.

National guidance recommends the development of more specific bioregional objectives to support these national goals.

For the purposes of this Science Advisory Report (SAR), and for consistency with the *National Framework*, a protected area is defined as, "*A clearly defined geographical space recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.*" (International Union for the Conservation of Nature definition). Depending on the level of protection provided to the area, this could include MPAs designated under the *Oceans Act*, National Marine Conservation Areas designated by Parks Canada, areas designated under the *Canadian Wildlife Act*, provincially protected areas, as well as areas protected under other legislation.

Guidance for Canadian MPA network planning and design is outlined in the *National Framework*, as well as in a Fisheries and Oceans Canada (DFO) SAR entitled *Science Guidance on the Development of Networks of Marine Protected Areas* (DFO 2010). Both documents recommend that bioregional planning follow the technical guidance on establishing MPA networks provided by the Convention on Biological Diversity (CBD) Conference of the Parties 9 Decision IX/20, including Annexes I-III (UNEP 2008). Marine bioregions were defined in a national Science Advisory Report (DFO 2009).

The CBD guidance states that effective networks should include: Ecologically or Biologically Significant Areas (EBSAs), representativity, connectivity, replicated ecological features, and adequate and viable sites (Annex II). Thus, networks should protect EBSAs and representative examples of all ecosystem or habitat types through individual MPAs that are connected via ecological processes with sufficient size and protection level. Annex III suggests that the initial steps in designing networks of MPAs are: (1) the scientific identification of EBSAs, and (2) the selection or development of a suitable biogeographic, habitat, or community classification system that can be used as a basis for representativity. Annex I provides criteria for identifying EBSA (Table 1).

Table 1. Convention on Biological Diversity criteria for identifying EBSAs.

Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features
Special importance for life history stages of species	Areas that are required for a population to survive and thrive.
Importance for threatened and endangered species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.
Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.

Through prior DFO ocean planning work, the Scotian Shelf Bioregion was previously subdivided into three planning areas: Atlantic Coast of Nova Scotia, Bay of Fundy and Offshore Scotian Shelf (Figure 1).

ASSESSMENT

Draft Conservation Objectives

Two overarching conservation objectives proposed for a network of marine protected areas in the Scotian Shelf Bioregion were discussed at the meeting, and the following wording was considered to be consistent with national and international guidance:

- Protect Ecologically or Biologically Significant Areas and other special natural features in the Scotian Shelf Bioregion that benefit from long-term, year-round, spatial management.

- Protect representative examples of all marine ecosystem and habitat types in the Scotian Shelf Bioregion based on coastline, coastal subtidal, and offshore classifications, along with their associated biodiversity and ecological processes.

While not explicitly stated in these overarching objectives, the connectivity between individual MPAs, replicated ecological features, and adequate and viable sites are also important considerations in MPA network design. To be an effective or ecologically coherent network, the linkages between MPAs should enhance their individual benefits (i.e., the sum should be greater than the parts, through larval or other life-history stage linkages for particular populations, species exchange, or other functional linkages). It may be useful to develop an explicit MPA network objective related to connectivity as knowledge of the Scotian Shelf Bioregion improves. Connectivity will be addressed along with the other design properties of replicated ecological features and adequate and viable sites during the network design phase.

Bioregional network objectives should ultimately be specific enough to be measurable and achievable. This may require development of more specific conservation objectives for each planning area under the two overarching conservation objectives related to the protection of EBSAs and representative areas.

While it may be too early in the MPA planning process to set targets for protection (e.g., percentages of representative ecosystems and habitat types), it is recognized that targets would facilitate discussion with stakeholders and assist with spatial analysis prior to final MPA network design. When targets are being explored in the network design phase, it may be useful to investigate a range of options to determine whether persistent patterns or areas emerge.

Representative Areas

DFO's *Science Guidance on the Development of Networks of Marine Protected Areas* (DFO 2010) states that, "... representative MPAs should capture examples of different biogeographic subdivisions that reasonably reflect the full range of ecosystems which are present at the scale of network development, including the biotic and habitat diversity of those ecosystems."

The subdivision of Canadian waters into marine biogeographic units (DFO 2009) identified the Scotian Shelf Bioregion, the boundary of which roughly corresponds to the current DFO Maritimes Region. The Scotian Shelf Bioregion has been further subdivided into three planning areas: the Atlantic Coast of Nova Scotia, Bay of Fundy, and Offshore Scotian Shelf. The Offshore Scotian Shelf encompasses the Scotian Shelf and Slope, the offshore portions of the Gulf of Maine that fall within Canadian jurisdiction, the Canadian portion of Georges Bank, and the oceanic and abyssal plain area out to the extent of the Canadian Exclusive Economic Zone (EEZ) (Figure 1).

While both coastal in nature, the physical conditions of the Atlantic Coast of Nova Scotia and the Bay of Fundy differ sharply. For example, the Bay of Fundy is largely sheltered from ocean swells, while the Atlantic Coast has practically unlimited fetch to the Atlantic Ocean. For the purpose of MPA network planning within the Scotian Shelf Bioregion, the seaward limit of the coastal zone can be defined as approximately 100 m in depth or roughly 12 nautical miles offshore (i.e., the inshore limit of the DFO research vessel trawl survey). Two separate but linked physiographic classification systems are recommended for the coastal zone, which are expected to largely reflect biological community patterns: the *coastline* and the *coastal sub-tidal* classifications.

> *Coastline*: the landward boundary is the inland limit of the marine waters, sediment and saline influences; the seaward boundary is 10 m of depth.
>
> *Coastal Sub-tidal*: the inshore boundary is 10 m of depth and the seaward (outer) boundary is approximately 100 m.

The proposed **coastline** classification is designed to separate physiographically distinct coastline classes at two main hierarchical levels (Greenlaw et al. 2012). The first level delineates the Atlantic coast from the Bay of Fundy and the Gulf of St. Lawrence coastline environments. The second level delineates "coastline segments" and "coastline sub-segments". It is recognized that finer-resolution classification would be useful for conservation planning to ensure that the breadth of habitat variability within each coastline segment is considered.

Major coastline environments are broken out where at least two features converge, including major oceanographic changes and major topographic and/or geological changes. Break points are made for coastline segments and coastline sub-segments when one or multiple variables clearly show a break in their pattern. Coastline segments are groupings of two or more coastline sub-segments. While the sub-segments may be physiographically distinct, they are grouped into segments because they meet one of the following criteria:

- They contribute to larger geomorphic units (e.g., keeping bays together).
- They represent aggregations/repeating of common landforms (e.g., repeating dunes).
- They are grouped by single unique features that are smaller in scale (e.g., Annapolis Basin).
- They are grouped into areas with minor differences.

Using this approach, the Bay of Fundy planning area includes 8 distinctive coastline segments with 15 sub-segments (Figure 2). The Atlantic Coast planning area includes 10 distinctive coastline segments with 17 sub-segments. In addition, the Bras d'Or Lakes include 2 sub-segments, and Sable Island is considered a separate coastal segment.

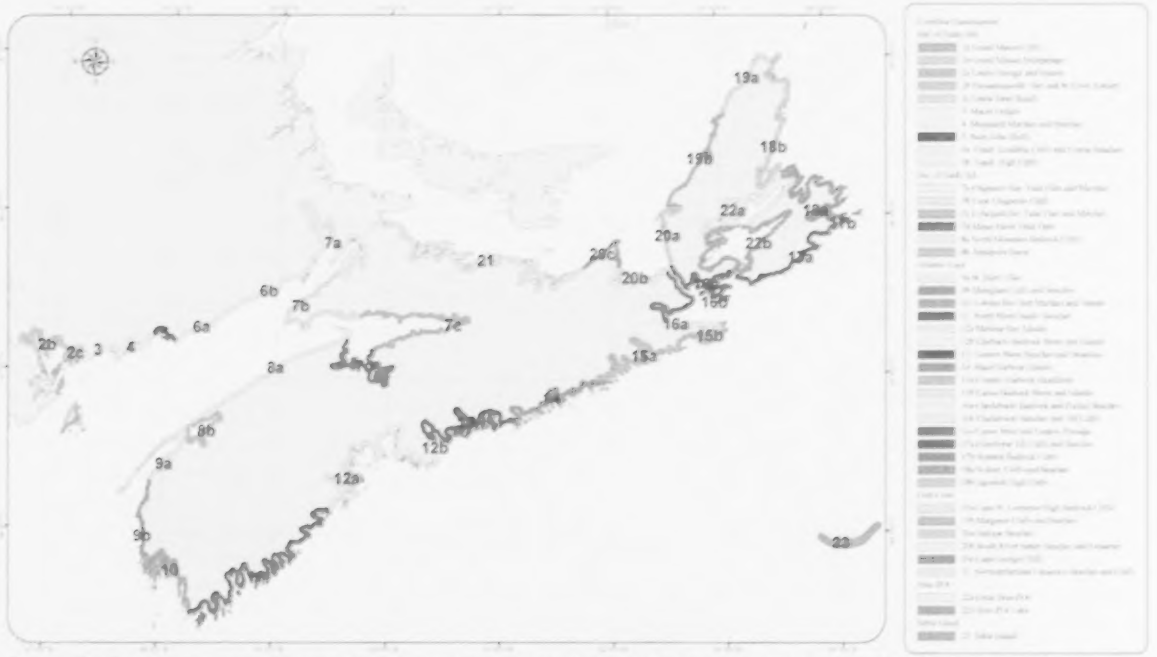

Figure 2. Distinctive coastal regions based on a physiographic coastline classification for the Scotian Shelf Bioregion. Note: not all segment numbers are visible on the map.

Since this classification was initially focused on the Atlantic Coast of Nova Scotia, with extension into the Bay of Fundy at a later stage, a recommended next step is to further validate the New Brunswick segments and sub-segments with local experts. Additional steps could include a multi-variate analysis to determine similarities between classes, comparison to biological data (such as marine bird data), and potentially a listing of the component habitats/ecosystems within each class. These steps are not necessary to begin using this classification in the initial stages of MPA network planning but should occur at a later stage. The proposed **coastal subtidal** classification is based largely on depth and substrate, which are more readily available than other factors and are, along with exposure, considered to be highly influential factors affecting species distribution and diversity in the coastal zone

(Greenlaw et al. 2012). Oceanographic factors were also incorporated into the classification but not weighted as highly as substrate and depth.

The coastal subtidal classification was designed to separate physiographically distinct coastal sub-tidal classes at four hierarchical levels. However, the first two levels of the classification are considered to be the appropriate scale for MPA planning purposes. These are:

- Large Scale Physiographic Regions
- Mid-Scale Physiographic Regions (separates coastal inshore and offshore differences)

The large and mid-scale subtidal classes were created using a weighted layer of substrate and coastal oceanographic factors. This combined layer was classified into distinct classes of oceanography and substrate, then similar physiographic regions were amalgamated at the mid and then large scales (Figure 3). The coastal subtidal classification was presented as a preliminary scheme, and boundaries of these classes may be refined upon further review.

While the seaward boundary of the coastal subtidal zone has been described as roughly 100 m, it is recognized that the coastal subtidal environment changes rapidly over the depth range of 10 – 100 m, with the transition from "coastal" to "offshore" waters occurring at some breakpoint not entirely determined by depth, e.g., photic zone. An MPA in the coastal subtidal zone that extends across the full depth gradient is likely to capture a larger range of habitat types.

Figure 3. Large (a) and Mid-Scale (b) sub-tidal physiographic classification (exact boundaries to be refined upon further review).

The preliminary coastal subtidal classification, along with the coastline classification, is suitable for use in the initial stages of MPA network planning as it provides a structured representation of distinct physiographic sub-divisions of the coastal zone at two principal hierarchical levels. Next steps include further review of the physiographic factor analysis and validating the sub-tidal classification with biological data (such as marine bird, plant and invertebrate data).

Two distinct classification systems are recommended for consideration in the **offshore**: a classification of seabed features, such as banks, basins, and channels (Fader unpublished report) and characterization using a benthic habitat template (Kostylev and Hannah 2007; DFO 2005). There is no need to combine the seabed feature classification and the benthic habitat template; they can be used as separate data layers for the identification of distinct classes of representative areas.

Fader (unpublished report) delineated the major seabed features of the Scotian Shelf Bioregion based on geomorphological and geological characteristics, which are recognized as the most enduring features of offshore marine environments (Figure 4). The benefit of this classification is that it extends out to the Exclusive Economic Zone (EEZ) and is easily described and understood.

Figure 4. Major seabed features (e.g., Banks, Basins, Channels) of the Scotian Shelf Bioregion as delineated by Fader (unpublished report).

The benthic habitat template (Kostylev and Hannah 2007) was previously reviewed through a DFO Science Advisory Process (DFO 2005) and includes a Scope for Growth component (Figure 5) and a Natural Disturbance (Figure 6) component. The Scope for Growth component integrates a variety of variables, including spring surface chlorophyll, summer stratification (surface to 50 m), annual average bottom temperature, annual range in bottom temperature, inter-annual variability in bottom temperature and bottom oxygen. The Natural Disturbance component describes the degree to which waves and currents disturb the substrate in different areas and integrates a variety of physical variables, including water depth, grain size, tidal currents, and wave height and period. Scope for Growth and Natural Disturbance can be mapped separately, and they may reflect/represent different processes. For example, Scope for Growth may better reflect the vulnerability of benthic communities to physiological stress, while Natural Disturbance may better reflect the vulnerability of benthic communities to physical disturbance (DFO 2005).

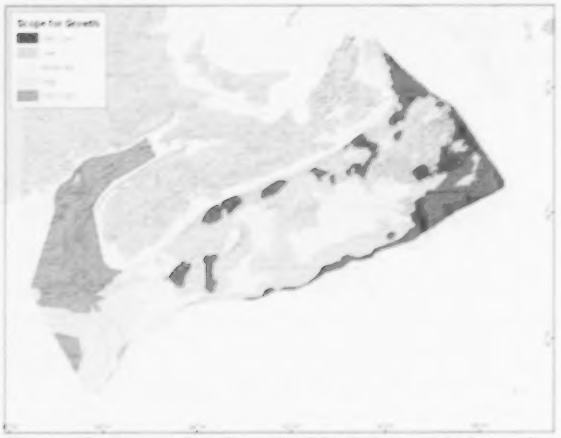

Figure 5. Scope for Growth (Kostylev and Hannah 2007).

Figure 6. Natural Disturbance (Kostylev and Hannah 2007).

These two components were combined into a single map (Figure 7) to better reflect the diversity of benthic community types in the Scotian Shelf offshore environment. It should be noted that this characterization does not extend out to the boundaries of the EEZ.

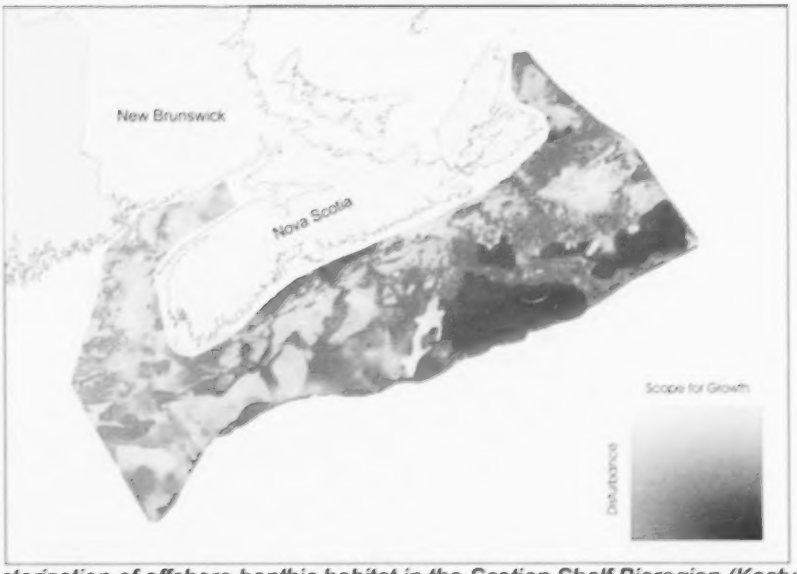

Figure 7. Characterization of offshore benthic habitat in the Scotian Shelf Bioregion (Kostylev and Hannah 2007).

A newly-developed statistical approach for analyzing the patterns and magnitude of changes in species composition along environmental gradients, "Gradient Forest" (Ellis et al. 2012), has been applied to seabed biodiversity data sets in the Gulf of Maine (in comparison with two other marine regions; Pitcher et al. 2012) and consideration should be given to applying this classification to the Offshore Scotian Shelf.

Ecologically or Biologically Significant Areas (EBSAs)

An EBSA is an area of particularly high ecological or biological significance that should receive a greater-than-usual degree of risk aversion in management of activities in order to protect overall ecosystem structure and function (DFO 2004).

Both DFO (2004, 2011) and the CBD (UNEP 2008) provide guidance on the identification of EBSAs and, although they differ slightly, it is generally accepted that following either the DFO or CBD criteria will result in the identification of similar areas. Moreover, areas that have consistently or persistently met the various EBSA criteria as they have evolved over time are likely to continue to be identified as EBSAs even if the criteria are modified again in the future. Moving forward with MPA network design in this bioregion, the CBD guidance will be used as the primary criteria for identifying EBSAs because the network is a shared initiative among federal and provincial agencies. If the network was the sole responsibility of DFO, it might be more appropriate to use the DFO EBSA criteria.

Not all areas that fit the criteria for EBSA according to the DFO and CBD guidance may be appropriate for inclusion as MPAs in the Scotian Shelf bioregional network. It is suggested that priority for inclusion as MPAs in this bioregional network be given to EBSAs that would benefit from long-term, year-round, spatial management. Special consideration should also be given to features that may persist or benefit from protection in the face of climate change, and EBSAs that can be prioritized based on their naturalness, vulnerability, and irreplaceability. While specific criteria (e.g., presence of a vulnerable species) may be used to identify a particular EBSA for consideration as an MPA, if it is included as an MPA within the bioregional network, management measures should consider all ecosystem components within that MPA. This would help to ensure each MPA in the network can contribute to ecosystem or habitat representation objectives. It may be necessary to prioritize certain areas within an EBSA for protection.

Due to varying levels of available biological and ecological data across the Scotian Shelf Bioregion, different approaches to identifying EBSAs have been used to date in the three planning areas.

Bay of Fundy

The Bay of Fundy is a globally significant natural feature. Its massive tides and water flow are among the many physical and biological reasons for its significance. It is coastal but includes offshore components.

An initial suite of potential EBSAs for this planning area was developed through a review of existing literature and the compilation of expert opinion during the early 2000s (Buzeta et al. 2003, Buzeta and Singh 2008). More recently, each potential EBSA was re-evaluated against the DFO and CBD EBSA criteria in an effort to validate and augment the original list.

In the Bay of Fundy, sixteen areas were found to meet the DFO and CBD criteria for EBSA, using extensive literature review, scientific expert opinion, and validation with available data (Appendix 1). Appendix 1 includes an indication of the specific EBSA attributes of each area. Approximate locations of each of these areas are provided in Figure 8.

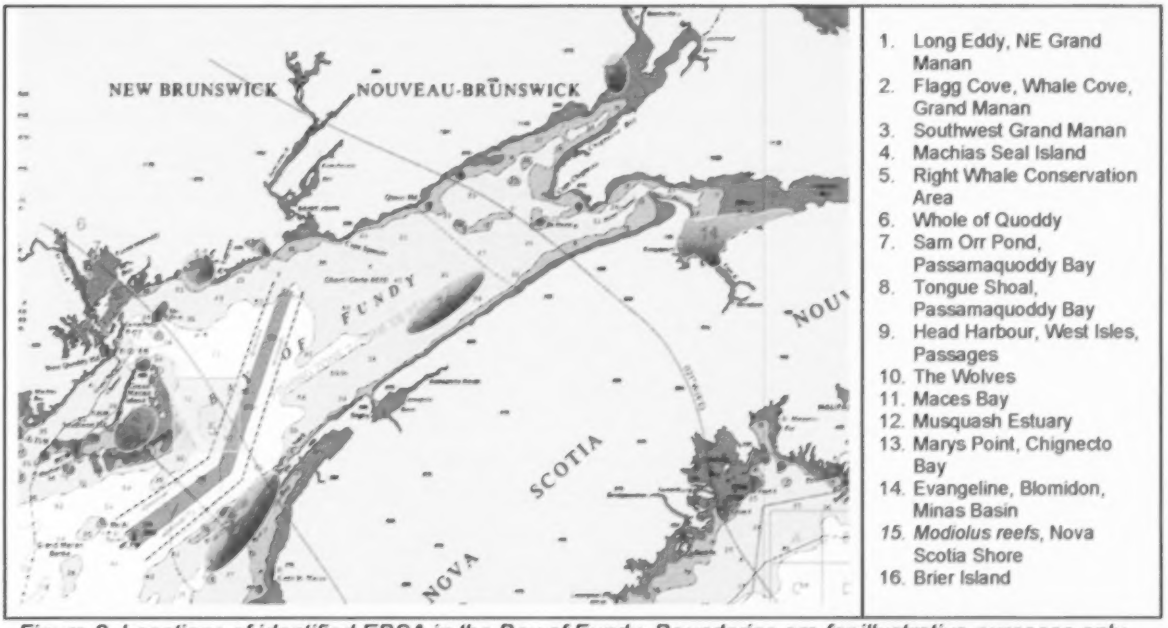

Figure 8. Locations of identified EBSA in the Bay of Fundy. Boundaries are for illustrative purposes only.

Next steps include the specific spatial delineation of each EBSA so they can be considered in the network design analysis. A process would also need to be developed to evaluate new EBSA as they are identified, e.g., through ongoing identification of critical habitat for species at risk. Connectivity between EBSAs may be enhanced through the inclusion of representative areas in the MPA network.

Atlantic Coast of Nova Scotia

The data available for the Atlantic Coast of Nova Scotia are different than those for the Offshore Scotian Shelf and Bay of Fundy planning areas, with few regionally based surveys (though complementary marine bird datasets were noted). In 2007, potential EBSAs on the Atlantic Coast of Nova Scotia were identified using scientific expert opinion at a *Workshop on Inshore Ecosystems and Significant Areas of the Scotian Shelf* (DFO 2007; Doherty and Horsman 2007). Forty-seven areas were identified for consideration using the DFO EBSA criteria. Gromack et al. (2010) collected ecological and human use information on 20 of these areas that met the *Oceans Act* MPA criteria from a variety of sources including primary and secondary literature, websites, government databases, unpublished data and other grey literature.

At the March 2012 meeting, the scientific context and assessment process undertaken in 2010 to identify areas that should be considered in conservation planning were reviewed. Twenty areas identified as meeting the criteria for DFO and CBD EBSA were endorsed for consideration in the bioregional MPA network design phase (Figure 9). Regional science experts identified a number of datasets and expert knowledge that had not been incorporated into the EBSA evaluation. It was recommended that the remaining 27 areas (of the original 47) should be re-evaluated against the CBD EBSA criteria, using expert knowledge and available regional information, to ensure potential priority areas for conservation, including those identified by Environment Canada, Parks Canada, and the Nova Scotia Government ,have not been overlooked. A final list of EBSAs to be considered in the MPA network design analysis should be developed and refined through ongoing discussions among federal and provincial partners and consultation with Aboriginal groups and stakeholders.

Additional vulnerability/risk or irreplaceability analysis may be required. Some consideration should also be given to the connectivity between EBSAs, especially as representative areas are factored into the MPA network design. Opportunities to enhance the relative value of a "coastal" MPA network in terms of connectivity (through establishment of boundaries and/or regulations) should not be overlooked.

1. Lobster Bay
2. Cape Sable Island
3. Port Joli / Kejimkujik Seaside Adjunct
4. LaHave River and Islands
5. Mahone Bay and Islands (Wildlife Management Area
6. St. Margaret's Bay
7. Eastern Shore Islands (Wildlife Management Area)
8. The Canso Ledges
9. Mira Bay and Scatarie Island
10. Bird Islands
11. St. Paul's Island
12. Bras d'Or Lakes
13. Port l'Hebert
14. Cole Harbour Estuary
15. Chezzetcook Inlet to Jeddore Harbour
16. Taylor Head to Sheet Harbour
17. St. Marys River and Watershed
18. Janvrin Islands
19. Big Glace Bay
20. Western Sydney Bight

Figure 9. Locations of identified EBSA along the Atlantic Coast of Nova Scotia. Boundaries are for illustrative purposes only.

Offshore Scotian Shelf

Given the availability of various regional datasets for the Offshore Scotian Shelf, a data-driven and systematic approach, built on expert knowledge of the ecology of the area, the survey methodologies and the data sets, is proposed for identification of EBSA in this planning area. This approach would include an evaluation of available data and how they could be applied to address the CBD EBSA criteria. The data layers used by Horsman et al. (2011) would be examined along with other potentially useful data layers. The final list of data layers would be mapped and eventually incorporated into the next iteration of the MPA network design analysis.

It is also proposed that the potential EBSAs identified through science expert opinion and local traditional knowledge (Doherty and Horsman 2007; MacLean et al. 2009) be re-evaluated against the CBD EBSA criteria using an approach similar to that applied in the Bay of Fundy and Atlantic Coast. The purpose of this step would be to ensure that known significant areas are not overlooked in the data-driven approach due to lack of finer scale data. For example, it is proposed that unique areas identified through scientific expert opinion be considered as potential EBSAs.

Useful data sources for identifying potential EBSAs in the offshore include site-specific information, as well as regional-scale data that can be used to characterize the relative spatial distribution of a particular ecosystem feature (e.g., species, communities) or characteristic (e.g., species richness) throughout the bioregion. To develop an accurate characterization of the relative distribution of a feature, the source data should have broad spatial coverage, span a significant period of time, and cover different seasons. The DFO summer research vessel survey, which has taken place annually since 1970 and spans most of the offshore components

of the Scotian Shelf and Bay of Fundy (Simon and Comeau 1994), is the only available long-term survey of this nature. Use of this data requires guidance from those with expert knowledge of the ecology of the area, the survey methodologies and the data sets. Additional sources of information and steps to address each of the CBD EBSA criteria are proposed below:

- *Uniqueness or rarity*: Re-evaluate areas identified through scientific expert opinion. Also consider an analysis of bathymetry data to identify unique geomorphological features. Include unique features captured by existing protected areas such as the Gully MPA, and other conservation measures such as the Stone Fence Coral Conservation Area, Northeast Channel Coral Conservation Area, and the Emerald Basin Russian Hat sponge community.

- *Special importance for life history stages of species*: Identify list of species (e.g., Ecologically Significant Species) that will be considered in the network design analysis. Map habitats for important life history stages of each species that will be considered in the network design and that would benefit from spatial management. Data sources will be species dependent. Best available data for each species group should be used.

- *Importance for threatened and endangered species and/or habitats*: Finalize list of relevant species and determine which should be considered in the MPA network design analysis (see above). Map important habitats for each species that will be considered in the MPA network design. Data sources will be species dependent. Use maps of Critical Habitat for species for which it has been defined under *Species at Risk Act*.

- *Vulnerability, fragility, sensitivity or slow recovery*: Update the coral layers used by Horsman et al. (2011) with most recent data from the Maritimes Region Coral Database. Consider inclusion of coral and sponge layers developed by Kenchington et al. (2010) using the Kernel Density Analysis method, or predictive habitat modeling, e.g., Maxent (Finney 2010). Work with regional experts to develop one relative distribution map for priority coral and sponge species.

- *Biological productivity*: Give consideration to persistent or recurring areas of high primary or secondary productivity (i.e., which may predict other important processes), in the network design analysis. Approaches for mapping these areas using remote-sensing satellite data could be explored (e.g., Platt et al. 1995).

- *Biological diversity*: Update the data layers used by Horsman et al. (2011), and explore the use of the Cook and Bundy (2012) stomachs analysis and Shackell and Frank (2000) larval fish analysis.

- *Naturalness*: This criterion can be used to identify EBSAs but may be more useful in helping prioritize among EBSAs. Mapping all human activities is currently being conducted and may help identify areas of relatively high naturalness.

The Offshore Scotian Shelf is generally considered data-rich compared to most marine regions; however, major spatial, seasonal/temporal and taxonomic data gaps still exist. For instance, most of the slope and abyssal seabed areas have not been surveyed, nor has the oceanic zone beyond the shelf break.

Next steps include the compilation and analysis of available data to identify and delineate EBSAs for the offshore planning area. To begin to design the network, the updated EBSA layers could then be combined with the representation layers (e.g., in a *Marxan* analysis) to identify a

set of areas of high conservation value. Connectivity, replication, and adequacy and viability should also be considered at this stage.

Sources of Uncertainty

The coastline classification was created using a Delphic process. In a Delphic process, typical issues that arise are that the decisions are sometimes subjective, and many of the classification breaks involve expert judgement by the core participants to the original process. This can result in difficulties in subsequent re-evaluation or testing of the derived classification by others. However, given the high level of knowledge of the experts involved, using a Delphic process was considered the best option to link some of the generally-accepted regional biological patterns to physiographic features within the region. This classification should eventually be validated against biological data (such as marine bird data) to ensure the physiographic patterns and classification breaks identified are reflective of biodiversity change across the coastal environments.

Some participants cautioned about the use of the coastline and coastal subtidal classifications with respect to the practical considerations of MPA network planning and the feasibility of adequately representing all of these classes within an MPA network. The main concern raised was the fine scale geographic focus of the classification schemes.

While exposure is recognized as an important driving factor in the coastal subtidal zone, due to lack of exposure data, the current classification does not incorporate this variable. This classification should also eventually be validated against biological data.

Information on the middle of the Bay of Fundy may be lacking in the EBSA analysis due to difficulties in sampling there.

While there are many sources of data available for the Offshore Scotian Shelf, one of the most commonly used sources of information on the biology of the region – the summer research trawl survey – provides a view of only one season and a relatively limited suite of species. Information on marine mammals, seabirds, and most species of marine invertebrates is limited. As well, information on most aspects of the biology of the Scotian Slope, Rise and Abyssal Plain is very limited and patchy.

The potential implications of broad changes in the state of the ecosystem, including those due to climate change, are not clear.

Seasonal closures and other management measures that do not meet IUCN protected area criteria may contribute to conservation objectives; however, the role of these types of management measures in the Scotian Shelf bioregional MPA network is yet to be determined.

CONCLUSIONS AND ADVICE

Two overarching conservation objectives proposed for a network of marine protected areas in the Scotian Shelf Bioregion were discussed at the meeting, and the following wording was considered to be consistent with national and international guidance:

- Protect Ecologically or Biologically Significant Areas and other special natural features in the Scotian Shelf Bioregion that benefit from long-term, year-round, spatial management.

- Protect representative examples of all marine ecosystem and habitat types in the Scotian Shelf Bioregion based on coastline, coastal subtidal, and offshore classifications, along with their associated biodiversity and ecological processes.

While not explicitly stated in these overarching objectives, the connectivity between individual MPAs, replicated ecological features, and adequate and viable sites are also important considerations in MPA network design. More specific and measurable conservation objectives under the two overarching objectives may need to be developed for each of the three planning areas.

Two separate but linked physiographic classification systems are recommended for the coastal zone, which are expected to largely reflect biological community patterns. Two distinct classification systems are recommended for consideration in the offshore.

In the Bay of Fundy, sixteen areas were found to meet the DFO and CBD criteria for EBSA, using extensive literature review, scientific expert opinion, and validation with available data.

For the Atlantic Coast of Nova Scotia, the scientific context and assessment process undertaken in 2010 to identify areas that should be considered in conservation planning were reviewed. Twenty areas identified as meeting the criteria for EBSA were endorsed for consideration in the bioregional MPA network design phase. For 27 additional areas (also previously identified), it was recommended that they be re-evaluated against the CBD EBSA criteria, using expert knowledge and available regional information, to ensure potential priority areas for conservation, including those identified by Environment Canada, Parks Canada, and the Nova Scotia Government, have not been overlooked.

Given the availability of various regional datasets for the Offshore Scotian Shelf, a data-driven and systematic approach, built on expert knowledge of the ecology of the area, the survey methodologies and the data sets, is proposed for identification of EBSA in this planning area. Scientific expert opinion can be used to identify and address gaps in this analysis, particularly related to the identification of unique or rare features and features within the oceanic (deep water) zone. As well, the potential EBSAs identified through science expert opinion and local traditional knowledge (Doherty and Horsman 2007; Maclean et al. 2009) could be re-evaluated against the CBD EBSA criteria using an approach similar to that applied in the Bay of Fundy and Atlantic Coast.

For all three planning areas, further work is required to determine which of the identified EBSAs (or parts thereof) should be included in the bioregional network of MPAs.

Information on threats and human use (i.e., socio-economics) will be important to consider in subsequent steps in the MPA network planning process (not necessarily at the same time). An iterative process can be used to refine the MPA network design until a configuration that satisfies the conservation objectives but reflects socio-economic concerns is agreed upon.

Although difficult to predict, the potential implications of broad changes in the state of the ecosystem, including those due to climate change, should be taken into account in the MPA network design process.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 5-7, 2012, meeting to review Marine Protected Area Network Planning in the Scotian Shelf Bioregion. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Buzeta M.-I., R. Singh, and S. Young-Lai. 2003. Identification of significant marine and coastal areas in the Bay of Fundy. Can. Man. Rep. Fish Aquat. Sci. 2635. 246p.

Buzeta, M-I., and R. Singh. 2008. Identification of Ecologically and Biologically Significant Areas in the Bay of Fundy, Gulf of Maine. Volume 1: Areas identified for review, and assessment of the Quoddy Region. Can. Tech. Rep. Fish. Aquat. Sci. 2788: vii + 80 p.

Cook, A.M., and A. Bundy. 2012. Use of fishes as sampling tools for understanding biodiversity and ecosystem functioning in the ocean. Mar. Ecol. Prog. Ser. 454:1-18.

DFO. 2004. Identification of Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Ecosystem Status Rep. 2004/006.

DFO. 2005. Framework for classification and characterization of Scotia-Fundy benthic habitats. DFO Can. Sci. Advis. Sec. Ecosystem Status Rep. 2005/071.

DFO. 2007. DFO/FSRS Inshore Ecosystem Project Data Synthesis Workshop; 19-20 March 2007. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2007/028.

DFO. 2009. Development of a Framework and Principles for the Biogeographic Classification of Canadian Marine Areas. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/056.

DFO. 2010. Science Guidance on the Development of Networks of Marine Protected Areas (MPAs). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/061.

DFO. 2011. Ecologically and Biologically Significant Areas – Lessons Learned. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/049.

Doherty, P., and T. Horsman. 2007. Ecologically and Biologically Significant Areas of the Scotian Shelf and Environs: A Compilation of Scientific Expert Opinion. Can. Tech. Rep. Fish. Aquat. Sci. 2774: 57 + xii pp.

Ellis, N., S.J. Smith, and C.R. Pitcher. 2012. Gradient Forests: Calculating importance gradients on physical predictors. Ecology 93: 156–168.

Finney, J.L. 2010. Overlap of predicted cold-water coral habitat and bottom-contact fisheries in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/067. vi + 26 p.

Government of Canada. 2011. National Framework for Canada's Network of Marine Protected Areas. Fisheries and Oceans Canada, Ottawa. 31 pp. Available at: http://www.dfo-mpo.gc.ca/oceans/publications/dmpaf-eczpm/docs/framework-cadre2011-eng.pdf (Accessed October 26, 2012).

Greenlaw, M.E., A.G. Gromack, S. Basquill, A. Lynds, D. MacKinnon, B. Taylor, D. Utting, J. Hackett, J. Grant, D. Forbes, F. Savoie, D. Berube, K. Connor, S. Johnson, K. Coombs,

and R. Henry. 2012. A Physiographic Coastline Classification of the Scotian Shelf Bioregion and Environs: The Nova Scotia Coastline and the New Brunswick Fundy Shore. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/051.

Gromack, A.G., K. Allard, D. Fenton, S. Johnston, and J. Ford. 2010. Ecological and human use information for twenty areas on the Atlantic coast of Nova Scotia in support of conservation planning. Can. Tech. Rep. Fish. Aquat. Sci. 2880: xiv + 226 p.

Horsman, T.L., A. Serdynska, K.C.T. Zwanenburg, and N.L. Shackell. 2011. Report on the Marine Protected Area Network Analysis in the Maritimes Region, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2917: xi + 188 p.

Kenchington, E., C. Lirette, A. Cogswell, D. Archambault, P. Archambault, H. Benoit, D. Bernier, B. Brodie, S. Fuller, K. Gilkinson, M. Lévesque, D. Power, T. Siferd, M. Treble, and V. Wareham. 2010. Delineating Coral and Sponge Concentrations in the Biogeographic Regions of the East Coast of Canada Using Spatial Analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/041. vi + 202 pp.

Kostylev, V.E., and C.G. Hannah. 2007, Process-driven characterization and mapping of seabed habitats, in Todd, B.J., and Greene, H.G., eds., Mapping the Seafloor for Habitat Characterization: Geological Association of Canada, Special Paper 47, p. 171-184.

MacLean, M., H. Breeze, and P. Doherty. 2009. Using fish harvester's Local Ecological Knowledge (LEK) in support of identifying Ecologically and Biologically Significant Areas on the offshore Eastern Scotian Shelf. Oceans and Habitat Report 2009-01. Fisheries and Oceans Canada, Dartmouth, NS. 49p.

Pitcher, C.R., P. Lawton, N. Ellis, S.J. Smith, L.S. Incze, C-L Wei, M.E. Greenlaw, N.H. Wolff, J.A. Sameoto, and P.V.R. Snelgrove. 2012. Exploring the role of environmental variables in shaping patterns of seabed biodiversity composition in regional-scale ecosystems. Journal of Applied Ecology 49: 670–679.

Platt, T., S. Sathyendranath, and A. Longhurst. 1995. Remote-Sensing of Primary Production in the Ocean – Promise and Fulfillment. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 348, 191–201.

Shackell, N.L., and K.T. Frank. 2000. Larval fish diversity on the Scotian Shelf. Can. J. Fish. Aquat. Sci. 57: 1747-1760.

Simon, J.E., and Comeau, P.A. 1994. Summer distribution and abundance trends of species caught on the Scotian Shelf 1970-92, by the research survey groundfish survey. Can. Tech. Rep.Fish. Aquat. Sci. 1953:x+145p.

UNEP. 2008. Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Ninth Meeting (UNEP/CBD/COP/DEC/IX/20), Decision IX/20 (CBD, 2008). http://www.cbd.int/doc/decisions/cop-09/cop-09-dec-20-en.pdf (Accessed October 26, 2012).

APPENDICES

Appendix 1. Ecologically and Biologically Significant Areas in the Bay of Fundy.

DFO EBSA Criteria	Uniqueness	Aggregation	Aggregation/ Fitness Consequences	Naturalness	Resilience	Aggregation	Aggregation/ Fitness Consequences
CBD EBSA Criteria	**Uniqueness, rarity**	**Biological diversity**	**Special importance for life strategies**	**Naturalness**	**Vulnerability, sensitivity, slow recovery**	**Biological productivity**	**Threatened/ endangered species or habitat**
1. Long Eddy, NE Grand Manan (GM)		Y	Y				
2. Flagg Cove, Whale Cove, GM	Y	Y	Y				
3. Southwest Grand Manan		Y	Y	Y			Y
4. Machias Seal Island		Y	Y				
5. Right Whale Conservation Area		Y	Y				Y
6. Whole of Quoddy	Y						
7. Sam Orr Pond, Passamaquoddy Bay	Y						
8. Tongue Shoal, Passamaquoddy Bay		Y					
9. Head Harbour, West Isles, Passages	Y	Y	Y	Y	Y	Y	Y
10. The Wolves		Y	Y	Y	Y		Y
11. Maces Bay			Y				
12. Musquash Estuary		Y		Y			
13. Marys Point, Chignecto Bay		Y	Y				
14. Evangeline, Blomidon, Minas Basin		Y	Y			Y	
15. *Modiolus reefs*, Nova Scotia Shore	Y	Y	Y		Y		
16. Brier Island	Y	Y	Y				

FOR MORE INFORMATION

Contact: Marty King
Ecosystem Management Branch
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, N.S., B2Y4A2
Tel: (902) 426-9926
Fax: (902) 426-3855
E-Mail: Marty.King@dfo-mpo.gc.ca

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Centre for Science Advice (CSA)
Maritimes Region
Fisheries and Oceans Canada
PO Box 1006, Station B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Telephone: 902-426-7070
Fax: 902-426-5435
E-Mail: XMARMRAP@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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